

ADDITIVE FOR RUBBER ELASTOMERS

BACKGROUND OF THE INVENTION

This application is a continuation-in-part of application US Serial No. 10/395,941, filed February 6, 2003.

This invention is directed to an additive/process aid for polymeric materials such as rubber elastomers. More particularly, this invention is directed to an additive/process aid for such polymeric materials to facilitate the processing and/or enhance the properties of the elastomers.

Polymeric materials such as rubber elastomers are used for the manufacture of various products including tire components such as tire tread, wedge compounds, sidewalls, bead filler and tire carcasses. However, it is well known that rubber elastomers tend to exhibit certain undesirable physical characteristics, such as, poor tear strength.

Tear strength or crescent tear is a measurement of the resistance of a material to tear forces. The higher the crescent tear measurement, the more difficult it is for the elastomer to be torn from whatever it is bonded to, such as steel.

Rubber elastomers also tend to exhibit weak tensile strength. Tensile strength is a measurement of the force at which a rubber elastomer can be expected to fail under a tension load. The tensile strength of the rubber elastomer is important in order to maintain its elasticity. Specifically, for rubber elastomers used in tires, the higher the tensile strength, then the more air pressure can be added to the tire, without fear of blowing the tire.

1 Finally, rubber elastomers tend to have a low
2 elastic limit or tan delta measurement. The tan delta
3 measurement is a measurement of the stress and strain
4 exhibited on the elastomer or the amount of force that
5 can be applied before the elastomer reaches its elastic
6 limit and fails. It is advantageous for numerous
7 applications to increase the elastic limit of rubber.

8 With particular regard to tire applications, it is
9 desirable to produce rubber elastomers or elastomeric
10 materials capable of exhibiting reduced hysteresis.
11 Such rubber elastomers when fabricated into components
12 for constructing articles such as tires, vibration
13 isolators, power belts, and the like, will display
14 properties of increased rebound, decreased rolling
15 resistance and reduced heat-buildup when subjected to
16 mechanical stress during normal use. Hysteresis refers
17 to the difference between the energy applied to deform
18 an article made from the elastomer and the energy
19 released as the elastomer returns to its initial, un-
20 deformed state. In pneumatic tires for instance,
21 lowered hysteretic properties are associated with
22 reduced rolling resistance and reduced heat build-up
23 during operation of the tire. These properties, in-
24 turn, result in lowered fuel consumption of vehicles
25 using such tires and prolonged tire life. A reduction
26 in the measured tan delta of the elastomer is
27 indicative of a reduction in the hysteresis of the
28 elastomer.

29 To address these undesirable physical
30 characteristics, process aids and/or additives were
31 introduced into the rubber elastomer composition.
32 Process aids are substances added to aid in the
33 production processing of the rubber elastomers.

1 Additives are substances added to improve specific
2 physical characteristics of the rubber elastomer.
3 Additives can also act as process aids and aid in the
4 processing of the elastomers.

5 Additives, such as calcium stearate and stearic
6 acid, were used as process aids. However, the
7 organic/organometallic nature of these substances
8 causes them to have limited thermal stability and shelf
9 life. Other prior process aids were products of
10 organic chemical reactions. However, these process
11 aids were not reproducible batch after batch and were
12 often prone to error. Additives, such as carbon blacks
13 and various silicas, were also added to improve, among
14 other things, the tensile strength of rubber
15 elastomers.

16 Thus, there is a need for a process aid which
17 overcomes the limitations of the prior additives, and
18 is a simple, low-cost product that improves the
19 physical characteristics of rubber elastomers by
20 providing increased tensile strength, elasticity and
21 tear strength.

22 SUMMARY OF THE INVENTION

23 In accordance with the present invention, there is
24 provided an additive/process aid for polymeric
25 materials such as rubber elastomers which overcomes the
26 limitations of earlier additives/process aids.

27 Further, in accordance with the present invention,
28 there is provided an additive/process aid which
29 provides a simple, quick, and low-cost, slow speed
30 mixture blend which produces a stable product. It also
31 improves the physical characteristics of rubber
32 elastomers, by providing, among other things, increased
33 tensile strength, elasticity, and tear strength.

1 The additive/process aid comprises a mixture of
2 comminuted or micronized shale/slate predominately
3 formed of aluminum, magnesium and/or iron silicates,
4 starch, a reactive resin component, a metal carbonate
5 and an acidic component such as a fatty acid or a
6 silica gel.

7 As used herein, comminuted shale/slate includes
8 gray slate flour (alumina silicate or ground shale) as
9 well as silicates of aluminum, magnesium and iron and
10 mixtures thereof. The gray slate flour is typically in
11 powder form to assist in its dispersion in the
12 polymeric material.

13 Starch may be obtained from most agricultural
14 crops; the dominant starch raw materials being potato,
15 cassava, corn and wheat. Corn starch is preferred and
16 the present invention is described with particular
17 reference to the use of the same.

18 The resin component is selected from the group of
19 reactive polyesters resins and epoxy resins. The
20 reactive cite of the polyester resin may comprise a
21 carbon-carbon unsaturation intermediate ester groups.
22 Preferred polyesters include those used in structural
23 applications such as reinforced laminates. The epoxy
24 resin may comprise a wide range of epoxies as described
25 below, but epoxidized soybean oil is preferred.

26 The metal carbonate preferably includes a metal
27 selected from Group IA or IIA of the Periodic Table.
28 Calcium carbonate is preferred and described below.

29 The acidic component may comprise silica gel or a
30 fatty acid. Useful fatty acids include stearic acid
31 and oleic acid.

1 The additive may be formulated with reduced
2 amounts of metal carbonate and increased amounts of the
3 remaining ingredients varying up to about: 30% flour,
4 35% starch, 15% resin, 5% metal carbonate and 15%
5 acidic component, by weight, wherein the aggregate
6 amount of the ingredients total 100%. On the other
7 hand, the metal carbonate may be increased and the
8 remaining ingredients reduced to about: 10% flour, 10%
9 starch, 5% resin, 70% metal carbonate and 5% acidic
10 component, by weight, wherein the aggregate amount of
11 the ingredients total 100%. Additive/process aids
12 having these "high" and "low" formulations have
13 provided improvements with acceptable trade-offs in
14 certain of the composition properties readily
15 identified by the skilled compounder.

16 In preferred compositions, the additive/processing
17 aid comprises from 10 to 30% shale/slate material, 10
18 to 35% starch, 5 to 15% resin, 10 to 40% metal
19 carbonate, 5 to 15% acidic component, by weight,
20 wherein the aggregate amount of the ingredients total
21 100%. More preferably, the additive/processing aid
22 comprises from 20 to 30% shale/slate, 20 to 35% starch,
23 5 to 10% resin, 20 to 35% metal carbonate, 8 to 15%
24 acidic component, by weight, wherein the aggregate
25 amount of the ingredients total 100%.

26 Preferred additive/processing aid compositions
27 including polyester resin and silica gel comprise from
28 20 to 29% gray slate flour, 18 to 28% corn starch, 4 to
29 8% liquid polyester, 10 to 20% calcium carbonate, 8 to
30 15% silica gel, by weight, wherein the aggregate amount
31 of the ingredients total 100%. More preferably, the
32 additive/processing aid contains about 29% gray slate
33 flour, about 28% corn starch, about 8% liquid

1 polyester, about 20% calcium carbonate, about 15%
2 silica gel, by weight, wherein the aggregate amount of
3 the ingredients total 100%.

4 Preferred additive/processing aid compositions
5 including epoxy resin and a fatty acid comprise from 20
6 to 30% gray slate flour, 20 to 35% corn starch, 5 to
7 10% epoxy, 10 to 20% calcium carbonate, 10 to 15% fatty
8 acid, by weight, wherein the aggregate amount of the
9 ingredients total 100%. More preferably, the
10 additive/processing aid contains about 25% gray slate
11 flour, about 25% corn starch, about 5% epoxy resin,
12 about 35% calcium carbonate, about 10% fatty acid, by
13 weight, wherein the aggregate amount of the ingredients
14 total 100%.

15 As noted above, the resin may comprise a polyester
16 resin or an epoxy resin. The resins are preferably
17 liquid at rubber processing conditions and have a
18 molecular weight of from about 200 up to about 10,000
19 or higher.

20 Suitable epoxy compounds comprise molecules having
21 at least one or more epoxide group per molecule and
22 include epoxidized alkanes, alkenes, cycloalkanes,
23 alkenes and other epoxidized polymers and chemicals.
24 For example, epoxy/ether, epoxy/hydroxyl, epoxy/ester,
25 epoxy/amine, ether/amine, and cycloaliphatic
26 ether/hydroxyl group. These compounds contain
27 aliphatic and/or cycloaliphatic groups. Examples
28 include Octyl Epoxy Tallate (Argus Chemical and Union
29 Carbide), Epoxyprene 25 and 50 (Epoxidized Natural
30 Rubber from Guthrie Latex), Epon (Epoxidized Bisphenol
31 A from Shell Oil Co.), Styrene Oxide (S500-6 Aldrich
32 Chemical Co.) and 1,2-Epoxy-3-phenoxypropane (24,848-7
33 Aldrich Chemical Co.). Epoxidized plant(or vegetable)

1 oils, such as epoxidized soybean oil © P Hall PARAPLEX
2 G62, Argus Chemical, Union Carbide and Harwick
3 Standard) and epoxidized linseed oil (Argus Chemical),
4 are most preferred.

5 The additive/processing aid is preferably added to
6 polymeric materials such as rubber elastomers or
7 plastic materials such as polyethylene, ethylene
8 propylene. The preferred rubber elastomers are
9 selected from the group consisting of natural rubber,
10 isoprene, chloroprene, halo-butyls, SBR rubber, butyl
11 rubber, neoprene, epichlorohydrin rubber,
12 polysulfonated rubber, silicone rubber and mixtures
13 thereof.

14 These and other aspects of the invention are
15 described below in further detail, the illustrated
16 embodiments being representative of only some of the
17 ways in which the principles and concepts on the
18 invention can be executed and employed.

19 DETAILED DESCRIPTION OF
20 PREFERRED AND ALTERNATE EMBODIMENTS

21 The present invention is directed to an
22 additive/process aid to facilitate the production
23 processing of rubber elastomers. Once added to the
24 rubber elastomers, the process aid tends to increase
25 tensile strength, elasticity, and tear strength of
26 these rubber elastomers.

27 The present invention is both an additive and a
28 process aid. It is an additive because it is part of
29 the final rubber product made by an end user. It is
30 also considered a processing aid because the additive
31 will aid dispersion and give the end user enhanced

1 properties associated with homogeneity as well as more
2 through-put of product in a manufacturing process.

3 Generally, it is desirable to prepare the
4 additive/processing aid within the preferred ranges of
5 ingredients. Deviations from these ranges may be
6 readily determined by designed compound evaluations
7 measured by the obtained properties. Although
8 deviations from these ranges may occur with trade-off
9 of various properties, the following observations have
10 been made rubber elastomers and additive/process aids
11 including gray slate flour, corn starch, liquid
12 polyester, calcium carbonate and silica gel.

13 Gray slate flour will typically be used in the
14 range of between 20 and 30%. It is preferable to stay
15 within this range since adding an excessive amount of
16 gray slate flour may cause scorching of the
17 additive/process aid and adding too little gray slate
18 flour causes the additive/process aid to exhibit a low
19 cure state or level of cure. Preferably, about 29 to
20 30% by weight of gray slate flour is added to the
21 additive/process aid. Gray slate flour helps to aid in
22 the reinforcement of the additive/processing aid.
23 Preferably, the gray slate flour has a particle size in
24 the range of 32 microns. Suitable commercially
25 available sources of gray slate flour include KeyStone
26 Corporation, sold under the name Gray Slate Flour.

27 Further, the additives/process aid should include
28 about 18 to 30% by weight of corn starch. Again, an
29 excess of corn starch tends to cause scorching of the
30 additive/process aid and a deficiency of corn starch
31 may cause the additive/process aid to exhibit a low
32 degree of cure. Preferably, about 28 to 30% by weight
33 of corn starch is added to the additive/process aid.

1 Corn starch tends to increase the tear strength
2 enhancements of the additive/process aid. Preferably,
3 unhydrolyzed corn starch is added to the
4 additive/process aid. A suitable corn starch is
5 marketed by American Maze Corporation under the
6 designation Unhydrolyzed Corn Starch.

7 The additive/process aid also comprises at least
8 4% by weight and up to about 8% by weight of liquid
9 polyester. It is preferred to observe this range since
10 too much polyester tends to inhibit the incorporation
11 of the additive/process aid into the rubber. On the
12 other hand, if too little of the polyester is used,
13 scorching of the product tends to occur. Liquid
14 polyester helps to aid in the reinforcement of the
15 additive/process aid. Preferably, the liquid polyester
16 is clear when added to the additive/process aid.
17 Suitable commercially available sources of liquid
18 polyester include Dynatron Corporation of Atlanta,
19 Georgia, the product being sold with the designation
20 Liquid Polyester Resin.

21 Calcium carbonate should be included in the
22 additive/process aid in accordance with the preferred
23 ranges of from about 10% to about 35% by weight.
24 Permissive ranges of calcium carbonate vary from 5 to
25 70% by weight as indicated in the "high" and "low"
26 compositions described above. However, excessive
27 amounts of calcium carbonate may tend to cause
28 scorching of the additive/process aid and, too little
29 calcium carbonate, may result in a low degree of cure
30 of the additive/process aid. Preferably, about 20% to
31 about 40% by weight of calcium carbonate is used, and
32 more preferably, from about 32% to about 37% by weight
33 is used. Calcium carbonate improves the dispersion of

1 the additive/process aid. Preferably, calcium
2 carbonate is in a white form when added to the
3 additive/process aid. Calcium carbonate is available
4 from the Akrochem Company and from the J. Huber
5 Company, under the name Snowwhite Calcium Carbonate.

6 The silica gel should also be used in the
7 preferred 8 to 15 % by weight range. Excess of amounts
8 of silica gel tend to cause scorching on the
9 additive/process aid and, too little silica gel, tends
10 to result in a low degree of cure. Preferably about
11 15% by weight of silica gel is used. Silica gel may be
12 added in the form of pellets or powder. Silica gel
13 helps to absorb water from the additive/process aid and
14 promotes more uniform dispersion. Preferably, the
15 silica gel is in a white form when added to the
16 additive/process aid. Silica gel may be obtained from
17 U.S. Silica Corporation under the name Minsil Silica
18 Gel.

19 The additive/process aid of the present invention
20 is prepared as a slow speed, mixer blend. The
21 components of the additive/process aid are added
22 together and mixed, and reacted under suitable time and
23 temperature conditions. Preferably, these components
24 are cured for 12 minutes at 307°F.

25 The additive/process aid of the present invention
26 provides many advantages when added to a elastomeric
27 material such as a rubber elastomer, including improved
28 mixing, extrusion and processing characteristics, and
29 improved tear strength. It also maintains shore A
30 hardness and the cure state of the rubber elastomer.
31 Further, it increases tensile strength and elasticity
32 giving the rubber elastomer more flexibility. Finally,

1 it is a simple, low-cost additive/process aid, which
2 consistently produces a stable product.

3 The additive/process aid is preferably added to
4 rubber elastomers selected from the group consisting
5 of: natural rubber, isoprene, chloroprene, halo-butyls,
6 SBR rubber, butyl rubber, neoprene, epichlorohydrin
7 rubber, polysulfonated rubber, silicone rubber and
8 mixtures thereof. The rubber elastomers find
9 particular utility for tires, tire trends, carcasses
10 and sidewalls, coating stocks, hoses, belting, inner
11 tubes, inner liners, general-purpose rubbers and other
12 uses.

13 The additive/process aid is preferably added to
14 the rubber elastomer in the range of at least 1 phr and
15 up to 50 phr with consideration of the relative parts
16 of ingredients contained in the additive/process aid
17 itself. Preferably, the additive/process aid is added
18 to the rubber elastomer in the range of from at least 2
19 phr and up to 30 phr.

20 The present invention is further exemplified in
21 the following examples which illustrate the use of the
22 additive/process aid in a typical rubber compounding
23 recipe. It is understood that the examples are only
24 illustrative of preferred embodiments according to the
25 present invention wherein the claims set forth the
26 scope of the present invention.

27 EXAMPLE A

28 The ASTM 297 Test Recipe for Truck Tread Tires was
29 carried out, the resultant rubber elastomer from this
30 test was prepared having the formulation shown in Table
31 I.

TABLE I

1	2 RUBBER TEST RECIPE 3 Ingredients	Parts per Hundred of Rubber
4		
5	1. Natural Rubber (RSS or SMR-5)	53.6
6	2. cis-polybutadiene	13.4
7	3. napthenic process oil	36.0
8	4. stearic acid	2.0
9	5. zinc oxide	5.0
10	6. N-660 Black	10.0
11	7. nonox ZA	2.0
12	8. Santocure	0.8
13	9. Sulfur	2.0
14	10. Process Aid of Present Invention	30.0

15 The Rubber Test Recipe: First, rubber breakdown on a
16 mill is performed. Then, each powder-based ingredients
17 listed in Table I is added to the rubber mill, one at a
18 time, until all are incorporated, including the
19 additive/process aid of the present invention. The
20 additive/process aid of the present invention comprises
21 about 29% by weight of gray slate flour, about 28% by
22 weight corn starch, about 8% by weight of liquid
23 polyester, about 20% by weight of calcium carbonate,
24 and about 15% by weight of silica gel. Then, if there
25 are any oil-based ingredients listed in Table I, these
26 ingredients are mixed in last. Finally, the end
27 product is allowed to mill at least eight minutes.

COMPARATIVE EXAMPLE ONE

28
29 A rubber elastomer was prepared having the
30 formulation shown in Table II.

TABLE II

1	2	3	4	RUBBER TEST RECIPE Ingredients	Parts per Hundred of Rubber
5	6	7	8	9	10
				1. Natural Rubber (RSS or SMR-5)	53.6
				2. cis-polybutadiene	13.4
				3. napthenic process oil	36.0
				4. stearic acid	2.0
				5. zinc oxide	5.0
				6. N-660 Black	20.0
				7. N-990 Black	35.0
				8. nonox ZA	2.0
				9. Santocure	0.8
				10. Sulfur	2.0

15 The rubber elastomer composition was again prepared as
16 described above, in Example A.

COMPARATIVE EXAMPLE III

17
18 A rubber elastomer was prepared having the
19 formulation shown in Table III.

TABLE III

20	21	22	23	RUBBER TEST RECIPE Ingredients	Parts per Hundred of Rubber
24	25	26	27	28	29
				1. Natural Rubber (RSS or SMR-5)	53.6
				2. cis-polybutadiene	13.4
				3. napthenic process oil	36.0
				4. stearic acid	2.0
				5. zinc oxide	5.0
				6. N-660 Black	20.0
				7. nonox ZA	2.0
				8. Santocure	0.8
				9. Sulfur	2.0
				10. Silica 233	55.0

34 The rubber elastomer composition was again prepared as
35 described above, in Example A.

1 Once these three rubber elastomer compositions
2 were prepared, laboratory tests were run, using ASTM
3 297 test methods on each of the rubber elastomer
4 compositions. The tests were designed to test specific
5 physical characteristics, such as tensile strength, %
6 elongation, and crescent tear of the rubber elastomer
7 compositions. The results of each of the tests
8 performed on each of the Example rubber elastomers are
9 listed in the tables below.

9 listed in the table above.

10 Tensile strength is a measure of the force at

11 which a rubber elastomer can be expected to fail under

12 a tension load. The tensile strength of the rubber

13 elastomer is important in order to maintain its

14 elasticity. It is often desirable that reinforcing

15 agents are added to natural and synthetic rubbers to

16 increase tear strength.

TABLE IV

18	TENSILE STRENGTH	psi
19	Examples	
20	1. Example A	2750
21	2. Comparative Example One	2500
22	3. Comparative Example Two	2450

Percent elongation is a measurement of the stiffness of rubber. The higher the number, the harder the rubber composition to flux. It is often desirable that to add reinforcing agents to natural and synthetic rubbers to increase the percent elongation.

TABLE V

1		
2	PERCENT ELONGATION	
3	Examples	percent
4	1. Example A	535%
5	2. Comparative Example One	500%
6	3. Comparative Example Two	489%

7 Shore A hardness is a measure on the hardness of
8 rubber. It also provides or indicates the cure state
9 of a rubber composition. It is often desirable to and
10 the reinforcing agents to natural and synthetic rubbers
11 to maintain the Shore A hardness.

TABLE VI

12		
13	SHORE A HARDNESS	
14	Examples	Shore A hardness
15	1. Example A	61
16	2. Comparative Example One	61
17	3. Comparative Example Two	58

18 Crescent tear or tear strength is the force
19 necessary to propagate a crack or tear under stress on
20 a horizontal pull. It is often desirable to add
21 reinforcing agents to natural and synthetic rubbers to
22 increase tear strength.

TABLE VII

23		
24	CRESCENT TEAR	
25	Examples	Lb/inch
26	1. Example A	690
27	2. Comparative Example One	650
28	3. Comparative Example Two	632

29 Tan delta is a measure of the rolling resistance.
30 The lower the reading or tan delta value, the lower the
31 rolling resistance. It is often desirable to add

1 reinforcing agents to natural and synthetic rubbers to
2 decrease the tan delta.

3 TABLE VIII

4	TAN DELTA	
5	Examples	resistance
6	1. Example A	0.162
7	2. Comparative Example One	0.179
8	3. Comparative Example Two	0.192

9 The results of the rubber elastomer compositions
10 in Comparative Examples One and Two were compared to
11 Example A for changes in the physical properties
12 exhibited by the two rubber elastomer compositions. As
13 apparent from the above data, use of the
14 additive/process aid of the present invention (Example
15 A) resulted in significant increases in tensile
16 strength, percent elongation and crescent tear and
17 reduced tan delta measurements. Moreover, this rubber
18 elastomer composition also maintained its Shore A
19 hardness measurement. Accordingly, the
20 additive/process aid of the present invention imparts
21 favorable properties when utilized in association with
22 rubber elastomers.

23 Additionally, Example A contains the
24 additive/process aid of the present invention; it does
25 not contain large quantities of other additives/process
26 aids, such as silica or carbon black, as compared to
27 Comparative Examples One and Two. Thus, the improved
28 physical characteristics of the rubber elastomer
29 composition (Example A) are solely attributable to the
30 additive of the present invention.

31 The additive/process aid including epoxidized oil
32 and fatty acid is illustrated hereinafter. In a

1 preferred formulation, the additive/process aid
2 includes the following ingredients.

3 ADDITIVE/PROCESS AID COMPOSITION

4		DB6
5	Ingredient	(Wet. %)
6	gray slate flour	25
7	corn starch	25
8	epoxidized soybean oil	5
9	calcium carbonate	35
10	stearic acid	10

11 In accordance with the foregoing additive/process aid
12 formulation, a rubber elastomer composition Example B
13 in accordance with the invention was prepared together
14 with a Comparative Example Three or Control 3 as
15 reported in the following Table IX.

16 TABLE IX

17		EXAMPLE B	CONTROL 3
18		PER	PER
19	<u>MATERIAL</u>		
20	Natural Rubber (SMR20)	30.0	30.0
21	SBR 1520	70.0	70.0
22	Carbon Black (N339)	50.0	50.0
23	DB6	2.0	0.0
24	Sunder 750 T	10.0	10.0
25	Antioxidant (Santoflex 134)	2.0	2.0
26	Stearic Acid	2.0	2.0
27	Zinc Oxide	2.5	2.5
28	Akrowax 5030	2.0	2.0
29	Sulfur	2.0	2.0
30	Accelerator CBS ¹	1.7	1.7
31	Co-accelerator DPG ²	0.2	0.2
32	Final Total	174.4	172.4
33			
34	¹ N-Cyclohexyl-benzothiazolesulfenamide		
35	² Diphenylguaidine		

36 Mix Cycle: Example B and the Control were mixed in the
37 same manner except for the inclusion of DB6 in Example
38 B. Accordingly, the rubber and carbon black together

1 with DB6 in the case of Example B were mixed for 1.5
2 minutes at 60 RPM in a mixer preheated to 250°F. Oil
3 followed by Santoflex 134, stearic acid, zinc oxide and
4 Akrowax 5030 were added, and mixing continued to a
5 total mix time of 5.5 minutes. Then, the batches were
6 dumped, formed into sheets on a two roll mill and
7 allowed to cool.

8 Finish Cycle: The masterbatch followed by CBS, DPG and
9 sulfur are combined in a mixer preheated to 175°F and
10 mixed at 50 RPM for one minute or temperature increase
11 to 200°F, whichever came first. Each of the rubber
12 elastomers was then provided with 10 roll passes on a 2
13 roll mill followed by one cut pass.

14 The compositions of Example B and Comparative
15 Example Three were tested and the results are reported
16 below in Table X.

17 TABLE X

18		Example B	Control 3
19	<u>Processability Testing</u>		
20	Mooney Viscosity ML4@ 212°F	54	51
21	Monsanto Rheometer		
22	Minimum Torque, m-g	93.1	98.7
23	Maximum Torque, m-g	11.8	11.2
24	Scorch, t1, min.	5.67	5.67
25	90% Cure Time min.	13.83	13.00
26	<u>Physical Properties</u>		
27	<u>Stress-Strain Properties</u>		
28	Room Temperature 23°C		
29	50% Modulus, psi	285	259
30	100% Modulus, psi	573	510
31	200% Modulus, psi	1490	1351
32	300% Modulus, psi	2539	2368
33	Tensile Strength, psi	3042	2928
34	Elongation, %	351	357

TABLE X Cont.

1			
2	Elevated Temperature 100°C		
3	50% Modulus, psi	275	244
4	100% Modulus, psi	554	484
5	200% Modulus, psi	1301	1182
6	300% Modulus, psi	-	-
7	Tensile Strength, psi	1404	1449
8	Elongation, %	219	228
9	Shore A Hardness		
10	Room Temperature 23°C	70	70
11	Elevated Temperature 100°C	-	-
12	Tear Strength ASTM D624 Die C		
13	Room Temperature 23°C	193	190
14	Elevated Temperature 100°C	102	118
15	Bashore Resilience, %	41	41
16		62	60
17	<u>Dynamic Properties 1 Hz</u>		
18	5% Compression		
19	Elastic Modulus, E'		
20	26°C	8.05x10 ⁶	7.60x10 ⁶
21	75°C	6.63x10 ⁶	6.33x10 ⁶
22	122°C	6.05x10 ⁶	5.85x10 ⁶
23	Storage Modulus, E''		
24	26°C	1.80x10 ⁶	1.79x10 ⁶
25	75°C	1.08x10 ⁶	1.08x10 ⁶
26	122°C	0.812x10 ⁶	0.768x10 ⁶
27	Tangent		
28	26°C	0.223	0.235
29	75°C	0.163	0.170
30	122°C	0.134	0.131
31	10% Compression		
32	Elastic Modulus, E'		
33	26°C	6.81x10 ⁶	6.57x10 ⁶
34	75°C	6.04x10 ⁶	5.71x10 ⁶
35	123°C	5.77x10 ⁶	5.39x10 ⁶

TABLE X Cont.

1			
2	Storage Modulus, E"		
3	26°C	1.39x10 ⁶	1.47x10 ⁶
4	75°C	0.876x10 ⁶	0.931x10 ⁶
5	123°C	0.687x10 ⁶	0.651x10 ⁶
6	Tangent Delta		
7	26°C	0.204	0.223
8	75°C	0.145	0.163
9	123°C	0.119	0.121

10 The use of epoxy resin and fatty acids is further
11 illustrated in the following Examples C and D. More
12 particularly, Examples C and D illustrate variations in
13 the relative amounts or proportions of the ingredients
14 of the additive compositions in accordance with the
15 invention. More particularly, the additive/process aid
16 DB6H of Example C includes a lesser amount of calcium
17 carbonate in favor of relatively high amounts of the
18 remaining ingredients and the aid DB6L used in Example
19 D includes a relatively higher amount of calcium
20 carbonate with reduced amounts of the remaining
21 ingredients as summarized below.

ADDITIVE/PROCESS AID COMPOSITIONS

22			
23		DB6H	DB6L
24	Ingredient	(Wet. %)	(Wet. %)
25	gray slate flour	30	10
26	corn starch	35	10
27	epoxidized soybean oil	15	5
28	calcium carbonate	5	70
29	stearic acid	15	5

30 Examples C and D in accordance with the invention
31 respectively include additive/process aids DB6H and
32 DB6L together with the additional constituents shown in
33 the following Table IX. For comparison, a Control 4 or

1 Comparative Example Four was prepared as reported in
2 Table XI.

3 TABLE XI

4	EXAMPLE C	EXAMPLE D	CONTROL 4
5	PER	PER	PER
6	<u>MATERIAL</u>		
7	Natural Rubber		
8	(SMR20)	30.0	30.0
9	SBR 1520	70.0	70.0
10	Carbon Black (N343)	41.0	41.0
11	DB6H	2.0	0.0
12	DB6L	0.0	6.0
13	Aromatic Oil (Shell 750)	10.0	10.0
14	Antioxidant		
15	(Santoflex 13)	1.0	1.0
16	Stearic Acid	2.0	2.0
17	Zinc Oxide	2.5	2.5
18	Akrowax 5030	1.0	1.0
19	Masterbatch Total	157.5	159.5
20	Masterbatch	157.5	159.5
21	Sulfur	1.3	1.3
22	Accelerator CBS ¹	1.7	1.7
23	Co-accelerator DPG ²	0.2	0.2
24	Final Total	160.7	162.7
			166.7

25 ¹N-Cyclohexyl-benzothiazolesulfenamide
26 ²Diphenylguaidine

27 Masterbatch Mixing procedure: Start temperature 250°F,
28 RPM'S 40, add pre-blended polymers and carbon black
29 (together with DB6H or DB6L in Examples B and C), 0
30 minutes, mix for 1.5 minutes. Add oil followed by
31 antioxidant, stearic acid, zinc oxide and wax, increase
32 RPM to 60. Mix for 4 minutes and dump. Sheet out and
33 cool.
34 Final Mixing Procedure: Start temperature 175°F, RPM's
35 50. Add masterbatch, followed by remaining
36 ingredients. Mix keeping temperature below 200°F.
37 Dropped and performed 10 cut passes and 10 roll passes
38 on mill.

1 Examples C and D together with the Control 4 or
2 Comparative Example Four were cured for 15 minutes at
3 149°C and tested. The results of the tests are
4 reported below in Table XII.

TABLE XII

	Example C	Example D	Control 4
7 Rheometrics @ 149°C			
8 MH	72.60	75.36	73.94
9 ML	10.52	11.74	11.13
10 TC80	14.89	13.43	13.93
11 TC90	18.13	16.75	16.77
12 TS2	8.32	7.11	7.98
13 TS5	9.63	8.20	9.24
14 Mooney Viscosity			
15 ML(1+4)@100°C	40.31	45.19	40.30
16 Shore A Hardness			
17 Hardness@23°C	55.2	55.0	55.2
18 Hardness@100°C	66.2	67.4	66.0
19 Pendulum Rebound			
20 Rebound@23°C	52.7	56.3	53.2
21 Rebound@100°C	49.6	52.8	48.8
22 Stress-Strain Properties			
23 Results at 23°C			
24 100% Modulus, psi	192	235	183
25 200% Modulus, psi	474	618	451
26 300% Modulus, psi	1031	1314	956
27 Tensile Str., psi	2814	2962	2317
28 Elongation, %	534	496	500
29 Results at 100°C			
30 100% Modulus, psi	176	211	170
31 200% Modulus, psi	401	504	385
32 300% Modulus, psi	801	984	754
33 Tensile Str., psi	1225	1247	1182
34 Elongation, %	392	351	402
35 Tear Strength			
36 Pounds/in.@23°C	556.9	427.4	463.4
37 Pounds/in.@100°C	310.7	241.6	336.4
38 Specific Gravity	1.0746	1.0659	1.0686

TABLE XII Cont.

1

2 Tangent Delta¹

3 Tan Delta@ 5% strain 0.14305 0.13385 0.15172

4 % decrease from Control 5.714 11.778 na

5 Tan Delta@ 10% strain 0.13876 0.12925 0.14654

6 % decrease from Control 5.309 11.799 na

7 ¹(50°C, 1HZ, Strain Sweep)

8 As indicated by the foregoing comparisons, the
9 additive/process aid in accordance with the present
10 invention imparts increased tensile strength especially
11 under conditions of elevated temperature and high
12 strain. In addition, hysteresis is reduced as
13 indicated by the decrease in the tan delta values as
14 compared with the Control or Comparative Example Three.
15 Reduced hysteresis is associated with reduced rolling
16 resistance and reduced heat build-up during tire
17 operation or other cycled loading of the rubber
18 elastomer which give rise to lower fuel consumption
19 and/or increased elastomer product life.

20 Although preferred embodiments have been described
21 in detail, it should be understood that various
22 changes, substitutions, and alterations can be made
23 therein without departing from the spirit and scope of
24 the invention as defined by the appended claims. It
25 will be appreciated that various changes in the
26 details, materials and arrangements of parts, which
27 have been herein described and illustrated in order to
28 explain the nature of the invention, may be made by
29 those skilled in the area within the principle and
30 scope of the invention as will be expressed in the
31 appended claims.